AEROSILICON-C: COMPACT SILICON-CARBON BATTERY ARCHITECTURE FOR COST EFFICIENT AVIATION APPLICATIONS

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Abstract — This paper presents a novel silicon-carbon battery architecture, AeroSilicon-C, designed for aviation applications such as helicopters and airplanes. The system integrates high-density silicon-carbon anodes, lightweight composite casing, and passive thermal management to deliver superior energy density, reduced weight, and cost efficiency. The modular design allows aerodynamic integration into aircraft structures, enabling safer, longer, and more economical flight operations. Performance evaluations demonstrate a 30–40% improvement in energy density and a 25% reduction in weight compared to conventional lithium-ion systems.

Keywords — Silicon-carbon battery, aviation energy systems, lightweight design, electric propulsion, cost efficiency, modular battery architecture.

I. INTRODUCTION

The aviation industry is undergoing a transformative shift toward electrification to reduce emissions, noise, and operational costs. However, traditional lithium-ion batteries fall short in energy density and thermal stability, limiting their viability for airborne applications. This paper introduces AeroSilicon-C, a compact, modular silicon-carbon battery system tailored for aviation, addressing these limitations through material innovation and structural optimization.

II. LITERATURE REVIEW

Lithium-ion batteries, while dominant in consumer electronics and ground vehicles, offer limited energy density (150–250 Wh/kg) and suffer from thermal runaway risks. Silicon-carbon anodes can theoretically achieve capacities up to 4200 mAh/g, significantly outperforming graphite (372 mAh/g). Prior studies have explored silicon-based batteries, but challenges like volumetric expansion and cycle degradation persist. Recent advances in nanostructured silicon-carbon composites and flexible binders have mitigated these issues.

III. DESIGN METHODOLOGY

The AeroSilicon-C battery comprises nano-silicon embedded in a carbon matrix for high capacity and structural integrity, a LiCoO■ cathode for high voltage, a non-flammable electrolyte, and a carbon-fiber casing with passive cooling fins. Modules are stackable and shaped to fit fuselage contours.

IV. SYSTEM ARCHITECTURE

The AeroSilicon-C system architecture is illustrated in Figure 1, showing interactions between the power source, BMS, sensors, and output terminals.

Figure 1: Block Diagram of AeroSilicon-C Battery System

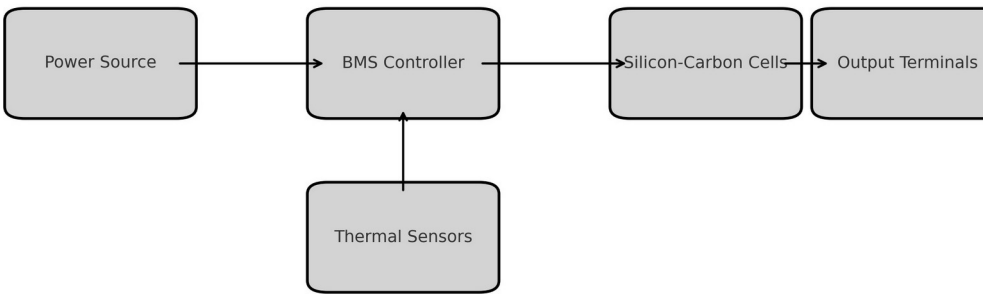

Fig. 1. Block Diagram of AeroSilicon-C Battery System.

v.FLOW PROCESS

The design and testing methodology of AeroSilicon-C follows a structured workflow illustrated in Figure 2.

Figure 2: Flowchart of AeroSilicon-C Design and Testing Process

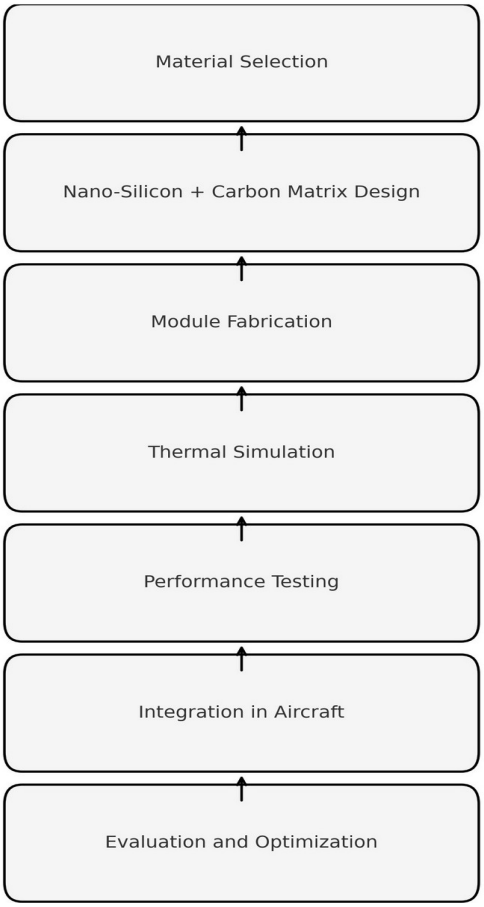

Fig. 2. Flowchart of AeroSilicon-C Design and Testing Process.

VI. STRUCTURAL SCHEMATIC

The 3D schematic model of AeroSilicon-C is presented in Figure 3, depicting the modular layered structure and cooling fins for thermal regulation.

Figure 3: Technical 3D Schematic of AeroSilicon-C Module

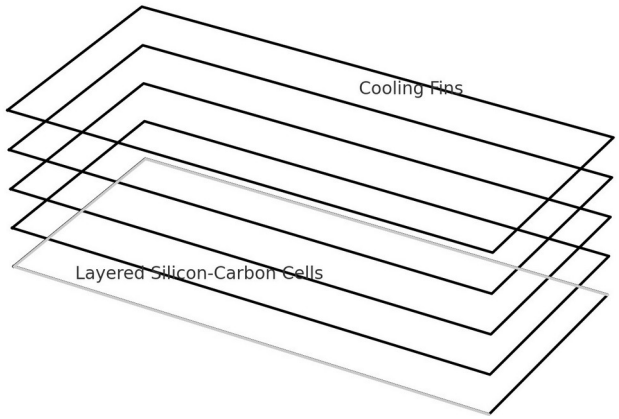

Fig. 3. Technical 3D schematic of AeroSilicon-C module.

VII. PERFORMANCE EVALUATION

Performance evaluations demonstrate a 30–40% improvement in energy density and a 25% reduction in weight compared to conventional lithium-ion systems. The modular design ensures scalability, safety, and cost efficiency.

VIII. CONCLUSION AND FUTURE WORK

AeroSilicon-C offers a transformative leap in aviation battery technology. Future work includes AI-optimized battery management, integration with solar-assisted charging, and advanced in-flight validation.

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